THIN LENS

Converging

Diverging

axis

axis

focal plane

f
Ray Tracing

Draw two rays from some object point. Their intersection is the image point.

1st ray:  Undeviated through center of lens.

2nd ray:  Parallel to the axis then bent at the lens so as to pass through the focal point
THIN LENS EQUATION

\[- \frac{h_o}{h_i} = \frac{d_o}{d_i}\]

\[- \frac{h_o^o}{h_i} = \frac{d_o}{d_i - f}\]

\[\frac{d_o}{d_i} = \frac{f}{d_i - f}\]
The thin lens equation:

\[ \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \]

Magnification:

\[ m = \frac{h_i}{h_o} = -\frac{d_i}{d_o} \]

Power of a lens:

\[ P = \frac{1}{f} \]

P is in units of diopters when f is in meters

Eyeglass prescriptions are specified in diopters.

Positive P is a converging lens.
Negative P is a diverging lens.
Sign Convention

(For Mirrors, Lenses, and Refracting Surfaces)

Note:

a) There is a side for which the light is incoming.

b) There is a side for which the light is outgoing.

For a mirror these are the same side!
For a lens they are opposite sides!

1. Object on incoming side:
   \(d_o > 0\) (real object); otherwise
   \(d_o < 0\) (virtual object)

2. Image on outgoing side:
   \(d_i > 0\) (real image); otherwise
   \(d_i < 0\) (virtual image)

3. \(f > 0\) converging lens
   \(f < 0\) diverging lens
Sign convention via a picture.

\[ \text{d}_i, \text{d}_o, f, \text{ and } h_o \text{ are all positive;} \]
\[ \text{h}_i \text{ is negative} \]

If \( \text{d}_o, \text{d}_i, \text{ or } f \) is on the opposite side of the lens, it will be negative.
LENS AND MIRROR COMBINATIONS

Light travels through an optical system and interacts with each lens/mirror in succession.

The image produced by the 1\textsuperscript{st} lens/mirror is the object for the 2\textsuperscript{nd} lens/mirror.

\[ \vdots \]

The image produced by the n\textsuperscript{th} lens/mirror is the object for the (n+1)\textsuperscript{th} lens/mirror.

\[ \text{etc.} \]

The overall magnification is the product of the magnification due to each lens/mirror.

\[ m = m_1 \times m_2 \times m_3 \times \ldots \]

The nature of the resulting image (real or virtual) is that of the image produced by the final lens/mirror in the optical system.